EFFECTIVENESS OF THREE TYPES OF VENTILATION OPENINGS IN FULL-TELESCOPE CORRUGATED CITRUS CARTONS

ARS-S-25
August 1973

AGRICULTURAL RESEARCH SERVICE • U.S. DEPARTMENT OF AGRICULTURE

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EFFECTIVENESS OF THREE TYPES OF VENTILATION OPENINGS IN FULL-TELESCOPE CORRUGATED CITRUS CARTONS

By Roy E. McDonald and Thomas H. Camp[1]

SUMMARY

A modified 7/10-bushel corrugated fiberboard citrus carton was tested and compared with conventional cartons of the same style. The modified carton has a larger total ventilation area than the conventional carton, and openings are all in the top and bottom of the carton.

The features and advantages of the modified carton, as identified in this study, are:

1. The modified carton can be stacked in register, so that cool air is forced to move through the carton instead of around it, resulting in more efficient air circulation.

2. Stacking refrigerated trailers in register results in greater load density and more stability in transit.

3. Stacking cartons in register utilizes their structural strength most effectively to protect the contents, whereas air-stacking cartons does not fully utilize structural strength, and increases the likelihood of carton failure, with damage to contents.

4. The modified carton can be palletized, reducing the cost of handling.

INTRODUCTION

Wirebound crates and wooden boxes were in general use as citrus shipping containers until displaced by corrugated fiberboard cartons in the 1940's. The construction of wood containers provided maximum air circulation, so that it was easy to maintain the product at optimum temperature and humidity.

As wood containers increased in cost, the cheaper corrugated fiberboard cartons replaced them. Corrugated fiberboard cartons have less open area than wire-bound crates or wooden boxes, which has caused problems in maintaining the product in optimum condition.

Research was undertaken in the late 50's and early 60's to develop loading patterns for shipping citrus in corrugated cartons by refrigerated rail cars and semitrailers. Such patterns required loaders to handle every carton, placing it in a precise position. Once in use, loading patterns became a roadblock to unitization and palletization.

The cost of loading and unloading rail cars and semitrailers has now risen to the point that larger quantities must be handled as single units. A unit composed of 54 cartons can be handled more efficiently and cheaply than single cartons. Unitized handling also reduces damage to cartons and their contents. Substituting a few movements of large units for many movements of small individual packages is one of the most effective ways to reduce marketing costs for agricultural and food products.

Carton failure, product damage, and inefficient handling techniques have created enormous waste in citrus (and other food) marketing. These problems, building over the years, were brought into clear focus when we began to export grapefruit to Japan and Western Europe. The basic problem was defined and a program of research was undertaken to develop more satisfactory ways of moving citrus through the marketing system.

An estimated 70 percent of Texas fresh citrus is packed and shipped in corrugated fiberboard cartons.[2] The cartons in use have ventilation

[1] Research horticulturist, Market Quality Research, Weslaco, Tex., and industry economist, Transportation and Facilities Research, Austin, Tex.

[2] 1971-72 Report of Texas Valley Citrus Committee, Pharr, Tex.

holes or slots variously located in the top, bottom, sides, and end panels. When loaded in refrigerated trailers or containers, these cartons are placed in an air-stack pattern so that cool air may circulate around and through the cartons. Although conventional cartons have proved satisfactory when air-stacked, they do not lend themselves to the tight stacking patterns required in palletization. To develop a carton that could be palletized, tests were initiated during the 1971-72 season on a modification of the conventional design. The modified carton has ventilation openings only in the top and bottom of the carton (fig. 1), while the conventional carton typically has openings in the sides.

SHIPPING TESTS

During the 1971-72 season, six paired shipping tests were made, comparing the conventional carton stacked in register (i.e., one carton placed carton stacked in register (i.e. one carton placed directly on top of another). In each of these tests, two refrigerated trailers with similar refrigeration, insulation and dimensional characteristics were used. One trailer, the control shipment, was loaded with conventional cartons in the air-stack pattern. The other trailer, the experimental shipment, was loaded with modified cartons stacked in register. The pairs of trailers were loaded at the same packinghouse, on the same day, bound for the same destination over the same route. Air circulation, cooling rates, and temperature were monitored. Air movement was measured by a hot-wire anemometer, and product temperatures were measured with Ryan recorders.

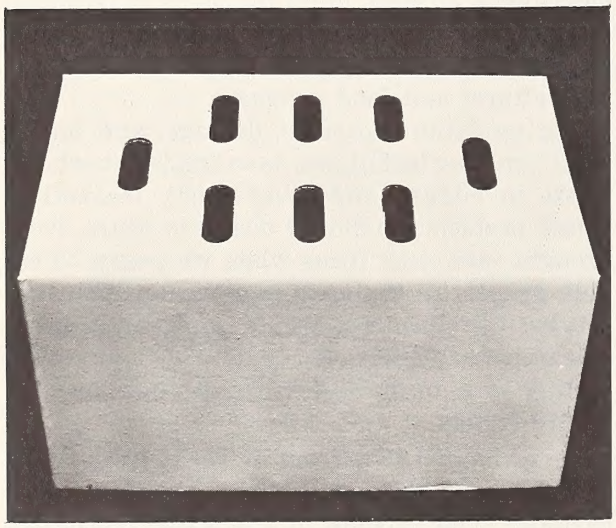

FIGURE 1.—Side and bottom view of modified corrugated citrus carton with ventilation slots in top and bottom of cover and body.

Airflow measurements comparing the conventional and modified cartons when both cartons were stacked in register were made in the Cooltainer-Van by William F. Goddard, ARS, USDA, Orlando, Florida.

RESULTS AND DISCUSSION

Cooling Rates

The cooling rates of citrus in modified and conventional cartons were compared in the four paired shipments (fig. 2-5). In shipments 1 and 4, the average product temperatures in the modified cartons stacked in register were slightly lower than in the air-stacked conventional cartons. In shipments 2 and 3 the average temperatures in the conventional cartons were slightly lower than in the modified cartons. These data suggest that cooling rates are of approximately the same magnitude when conventional cartons are air-stacked and when modified cartons are stacked in register.

Airflow

A hot-wire anemometer was used to determine airflow through the modified cartons stacked in register. The probe was placed between the ventilation slots of two cartons with the trailer refrigeration unit operating. Even with two nonperforated biphenyl pads per carton, vertical airflows average 25 linear feet per minute, indicating that with present commercial refrigerated trailer equipment, vertical airflows are obtained with the modified carton stacked in register.

Additional airflow comparisons were made between the conventional and modified cartons under laboratory conditions with both stacked in register. The cartons were filled with round plastic balls that approximate a size 80 orange, to simulate a load of citrus. Airflows, measured in cubic feet per minute, were slightly more than four times greater through the modified carton than through the conventional carton (fig. 6). No doubt this is because the open area is greater in the modified carton (0.151 ft^2) than in the conventional carton (0.036 ft^2).

(Continued on page 5)

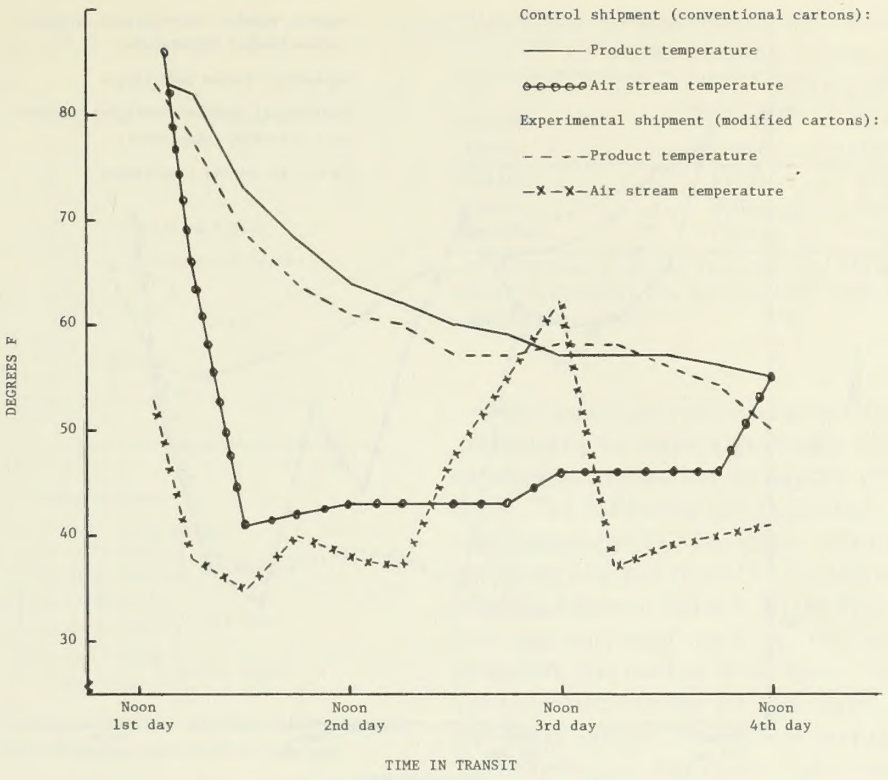

FIGURE 2.—Discharge air and average product temperatures (3 locations) in paired truck shipment 1.

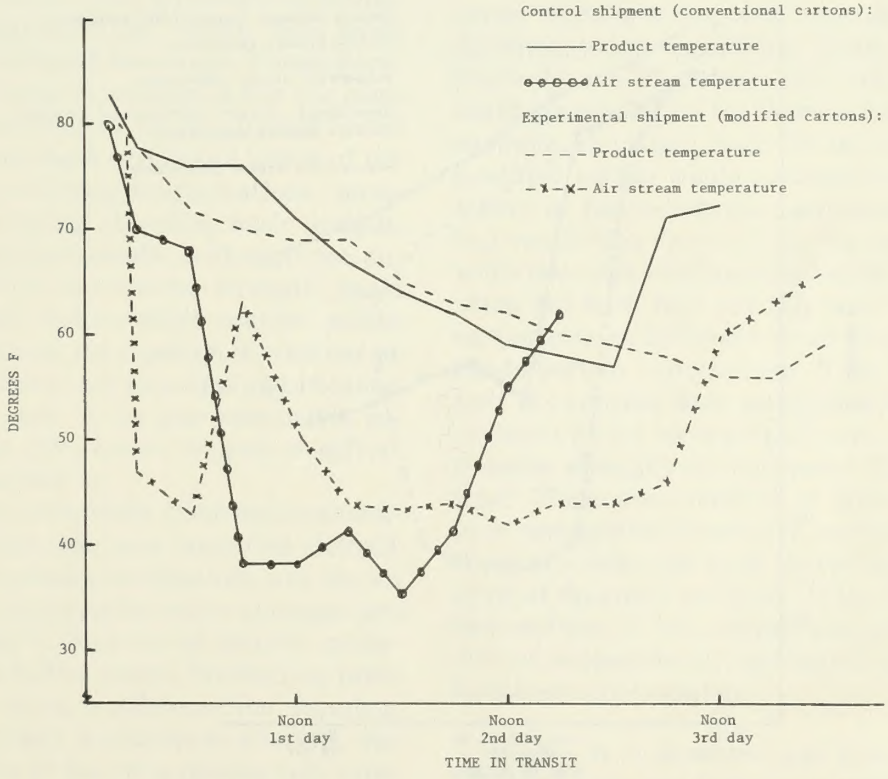

FIGURE 3.—Discharge air and average product temperatures (3 locations) in paired truck shipment 2.

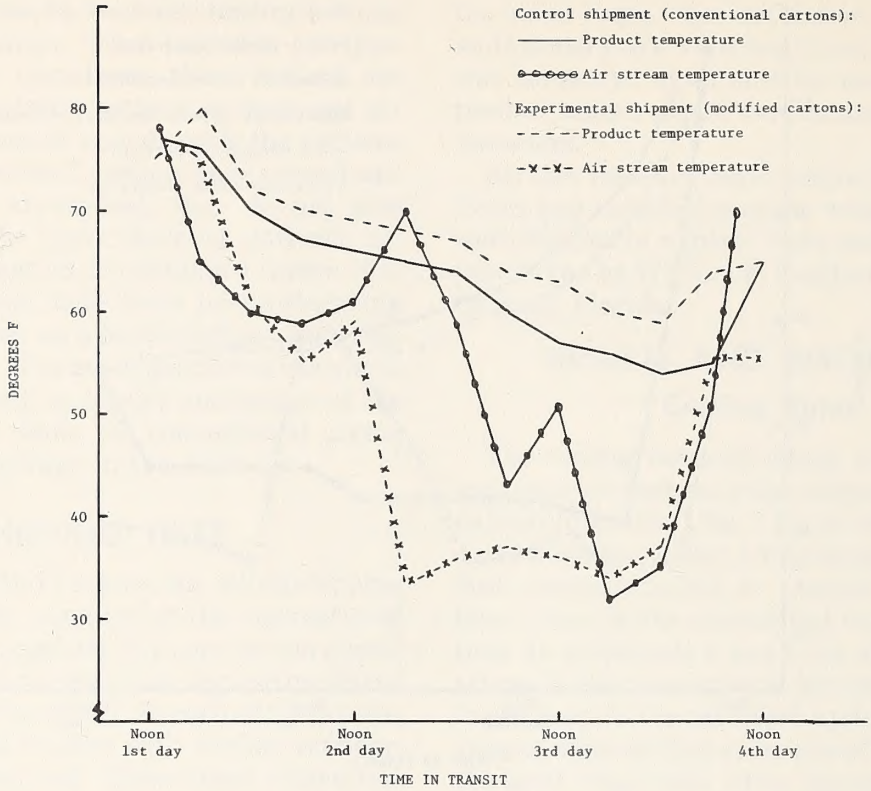

FIGURE 4.—Discharge air and average product temperatures (3 locations) in paired truck shipment 3.

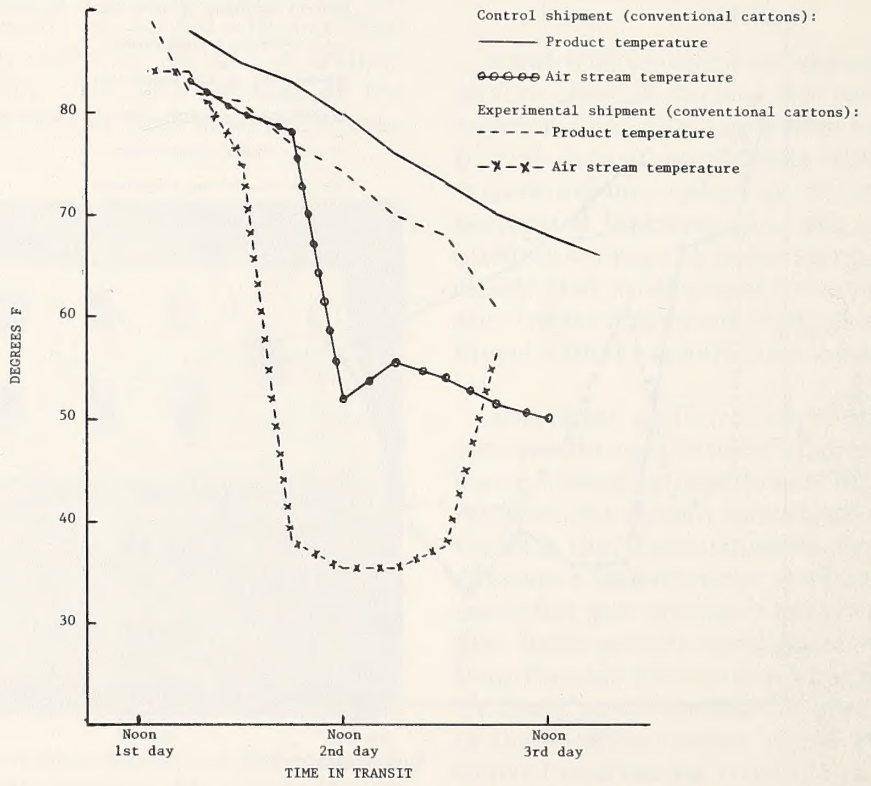

FIGURE 5.—Discharge air and average product temperatures (3 locations) in paired truck shipment 4.

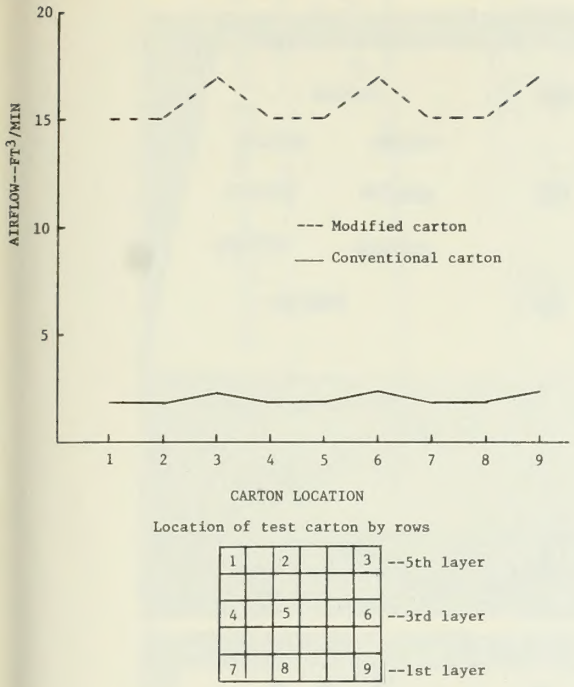

FIGURE 6.—Airflow measurements of the conventional and modified carton, made in the van.

COMPRESSION TESTS

Compression tests of two types of conventional cartons and the modified carton were made by the Forest Products Laboratory, Forest Service, USDA, Madison, Wisconsin. After the compression tests, samples of the corrugated board were removed from both covers and bodies of the cartons for the following determinations: moisture content, bursting strength, basis weight, and thickness measurements. Although the analysis of variations in bursting strength, basis weight, thickness, and moisture content points out some differences, the question is whether or not these differences have practical significance. There does not seem to be any reasonable explanation for the differences or lack of differences as the case may be.

The three types of cartons (conventional-slotted, conventional-holes, and modified-slotted) used in the compression evaluations are shown in figure 7; the compression value averages are compiled in table 1. Because of certain uncontrolled variables in the carton fabrication process (board production, box fabrication, forming, printing, and gluing) a statistical analysis was made to ascertain if the compression test averages were significantly different.

TABLE 1.—*Compression values of corrugated citrus cartons, in pounds*

Carton type	Maximum load[1]		
	Top-to-bottom	Side-to-side	End-to-end
Slotted	1772b	573a	310b
Holes	2005a	538ab	391a
Modified	1883ab	513b	344b

[1] Average of seven replications. Means not having a letter in common are statistically different at 1-percent significance level.

This analysis indicated that in all three directions there was a significant difference in the average compression strengths at the 1-percent level. The following are indicated: in top-to-bottom compression, the carton with holes was significantly better than the slotted carton, but the modified carton did not differ from either of the two conventional cartons; in side-to-side compression, the carton with holes was better than the modified carton, but not significantly different from either the slotted carton or the modified carton; in end-to-end compression, the carton with holes was significantly better than both the modified carton and the slotted carton.

Although the analysis indicates some differences, there is a question whether or not these differences are significant from the practical point of view. There does not seem to be any reasonable explanation for the observed values. For example, one might logically anticipate that the modified carton would perform better than the others in top-to-bottom compression because it had ventilation slots only in the top and bottom, while the other two types had holes or slots in the sides, yet such was not the case. The modified carton was no different from the other two in top-to-bottom compression. This tends to support the concept that ventilation or hand holes probably do not have a significant effect on compressive strength of corrugated fiberboard cartons.[3] There are a number of inherent variables in a corrugated fiberboard carton, and one of these in a telescope style carton is the accuracy of fit of the cover and body. If the depth of these two sections is not correct, the cover and body will act independently instead of together in top-to-bottom compression.

[3] Patchen, G. O. Effects of vent holes on strength of fiberboard boxes and fruit cooling rate. U. S. Dept of Agric., Agric. Res. Serv. ARS-52-34, 1969.

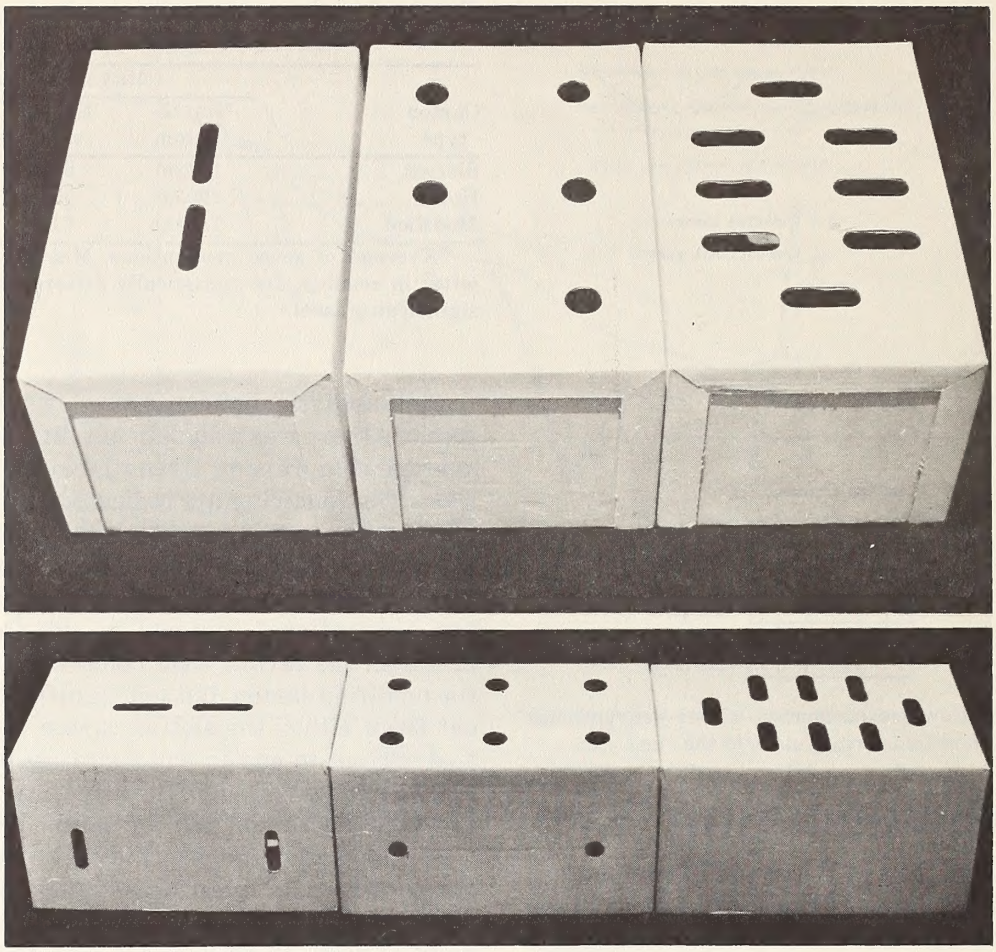

FIGURE 7.—Corrugated citrus cartons tested for compression strength. Above: cover—end and top view. Below: body—side and end view.

RECOMMENDATIONS

Additional research should be undertaken on palletized and unitized shipments of produce and should include:

1. Demonstration that stacking in register best utilizes the inherent structural strength of the carton.

2. Development of a standard carton to conform to the pallet sizes now used by the produce industry.